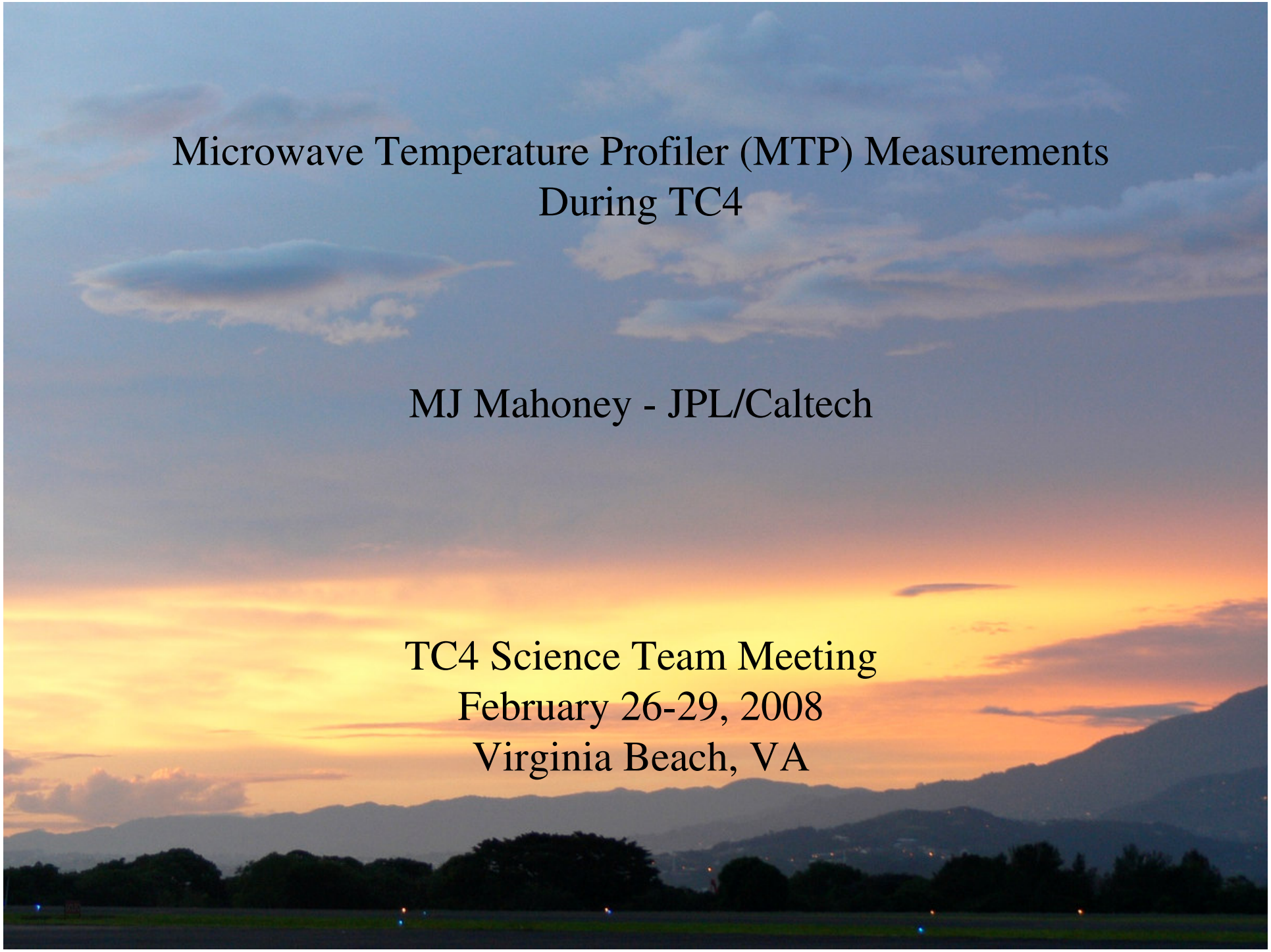

Microwave Temperature Profiler (MTP) Measurements During TC4

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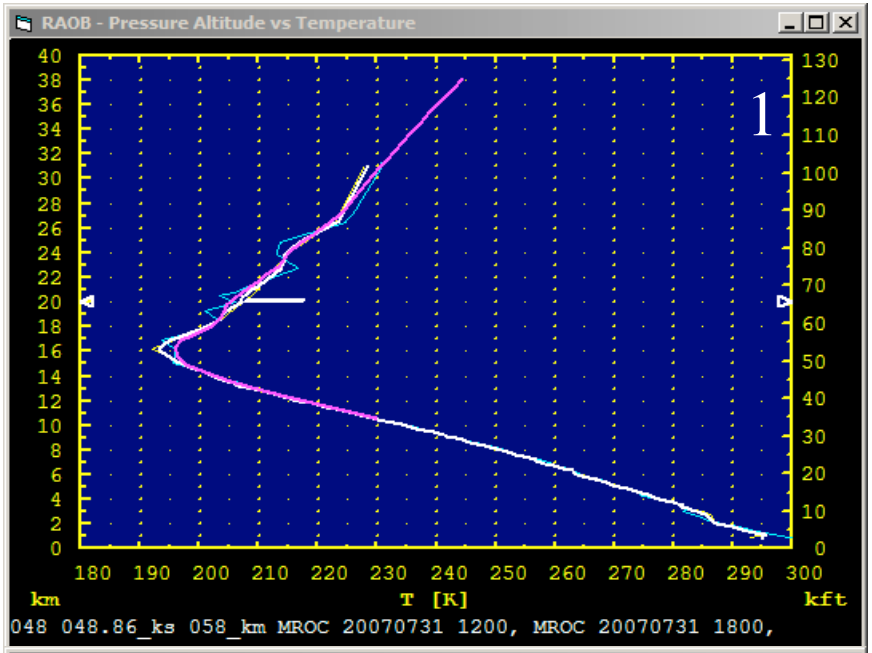
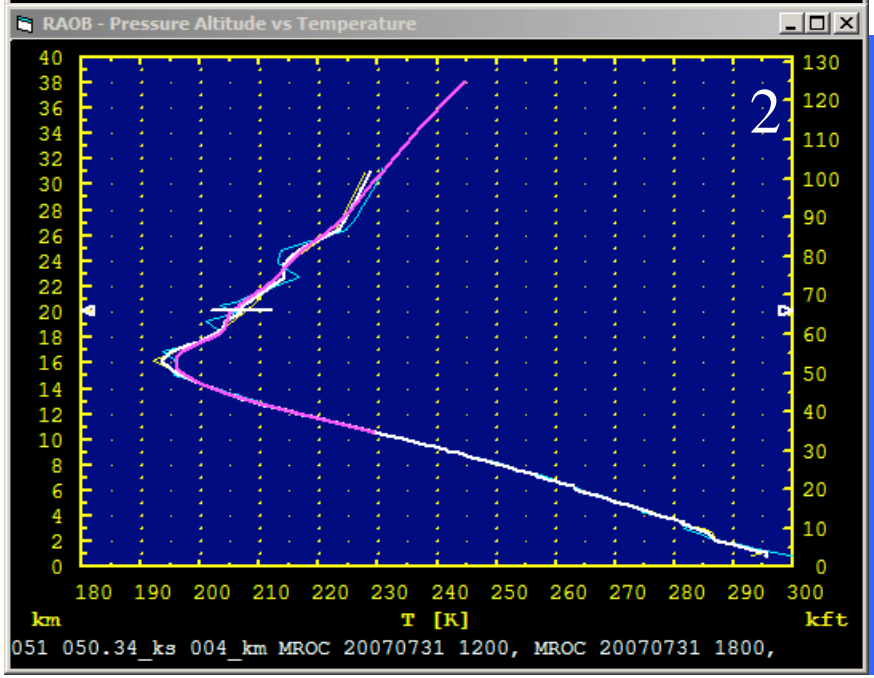
TC4 Science Team Meeting
February 26-29, 2008
Virginia Beach, VA

Abstract

The MTP flew on the ER-2 during TC4. In the process of calibrating the MTP flight level temperature against radiosondes, we have found that the outside air temperature reported by the ER-2 Navigation Data Recorder is unusable for science. It shows warm and cold biases in excess of 5 K, and in addition the reported temperature error is pressure altitude dependent. This problem has gotten significantly worse since we first noticed it during the SOLVE campaign in 2000. It was initially planned that the MTP fly on the WB-57 during TC4, where many experimenters rely on the MTP tropopause height determination to provide meteorological context their data. Since the ER-2 and WB-57 flew similar flight tracks during TC4, we have run simulations to assess the accuracy of MTP ER-2 tropopause height measurements so that they can be used by WB-57 experimenters. These results will be shown, along with other examples of MTP data products.

ER-2 Nav Data Recorder OAT Is Bad … And Has Been For Years!

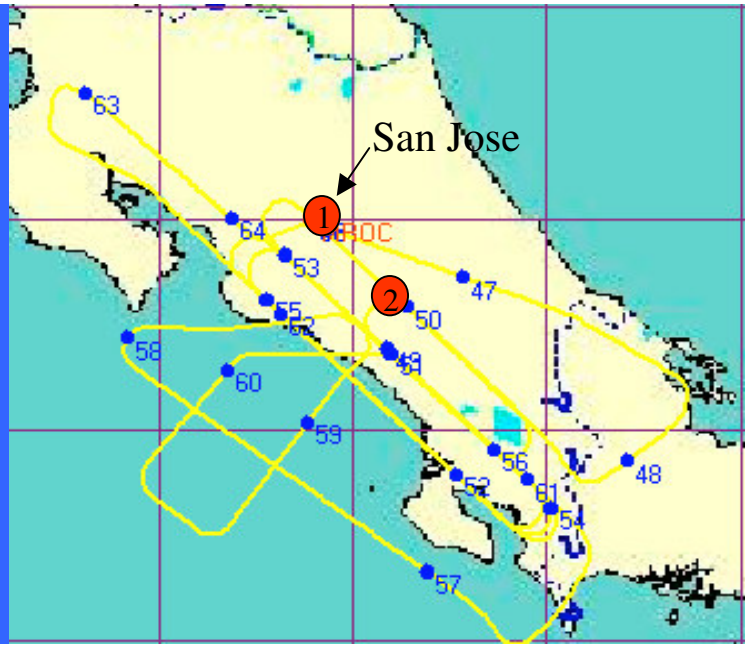




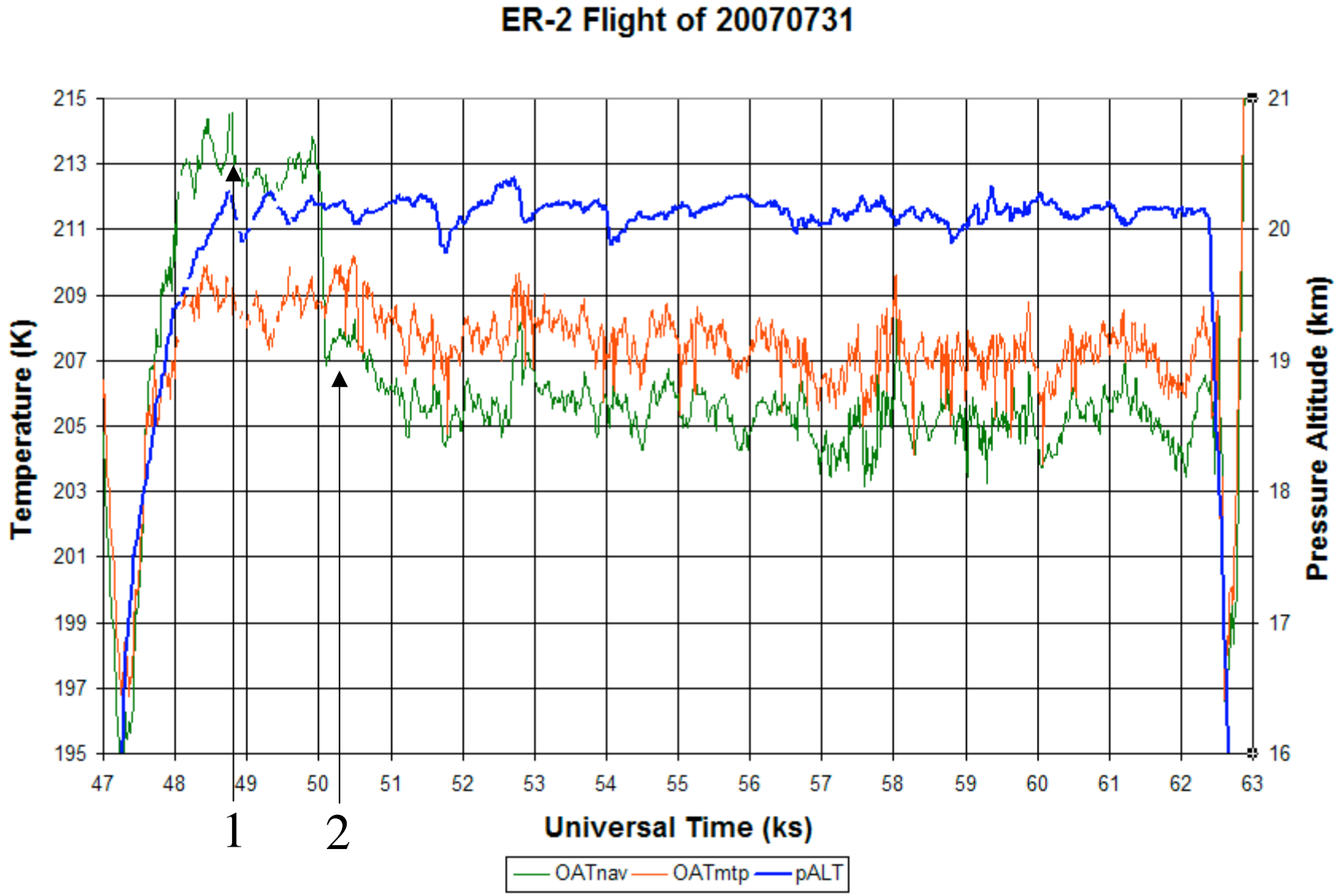
Soundings (left) from San Jose were interpolated (white trace) to the time of ER-2 closest approach at two locations 58 and 4.0 km away (red dots in map below). They were 25 minutes apart in time. The MTP retrieval (cyan) is excellent. The horizontal white bar shows the ER-2 altitude (~20 km) and the center of the bar is the OAT from the Nav Data Recorder. The temperature does not change by >5 K in 25 min!

Legend

Before RAOB
After RAOB
Interpolated
MTP

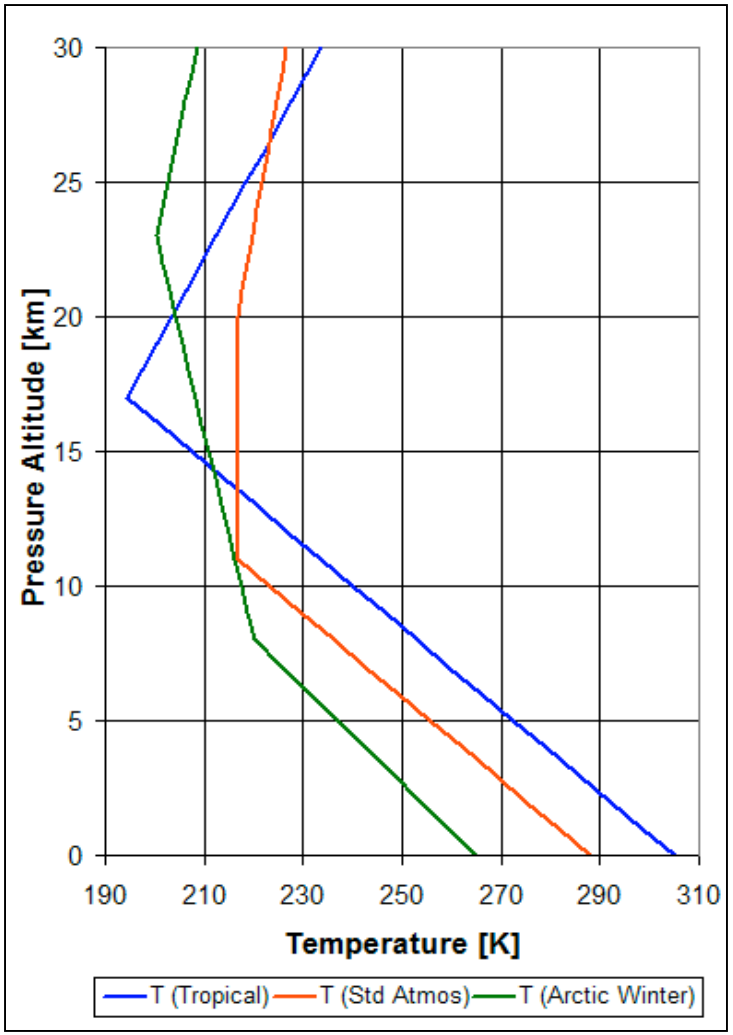


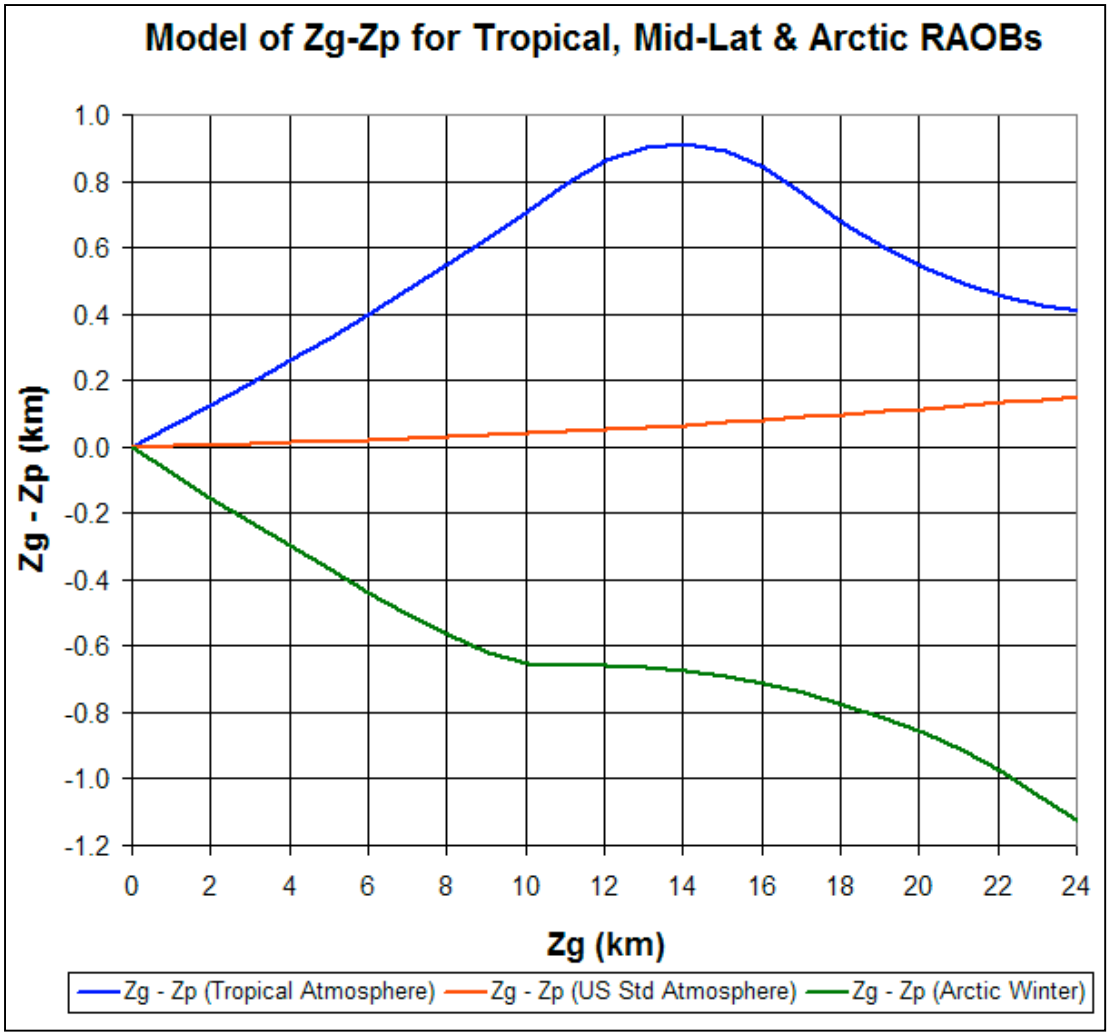
Time Series Comparing of OATnav and OATmtp



On this flight OATnav had a +5 K bias early on and -2 K during the remainder.

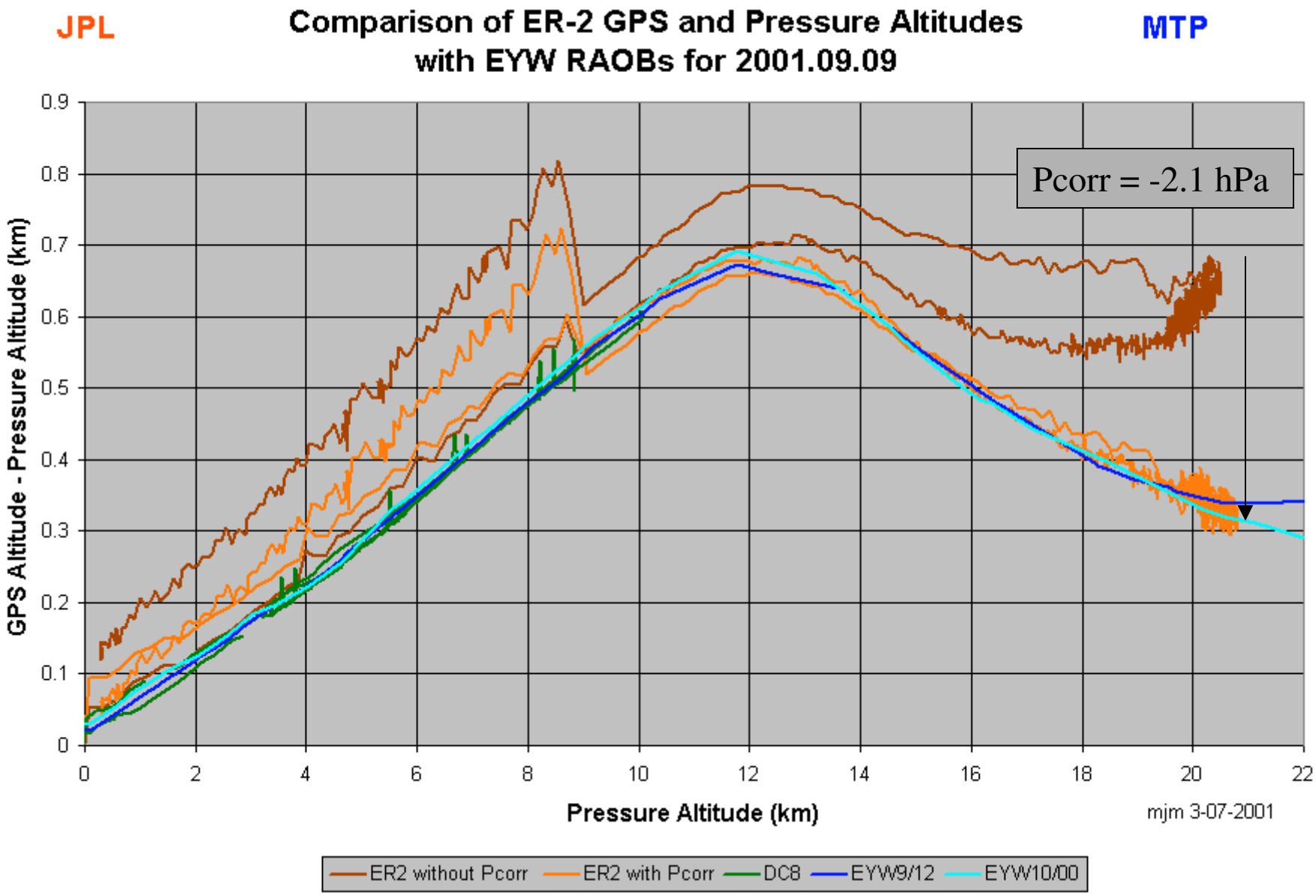
How to Determine if a Measured Outside Air Temperature is Valid



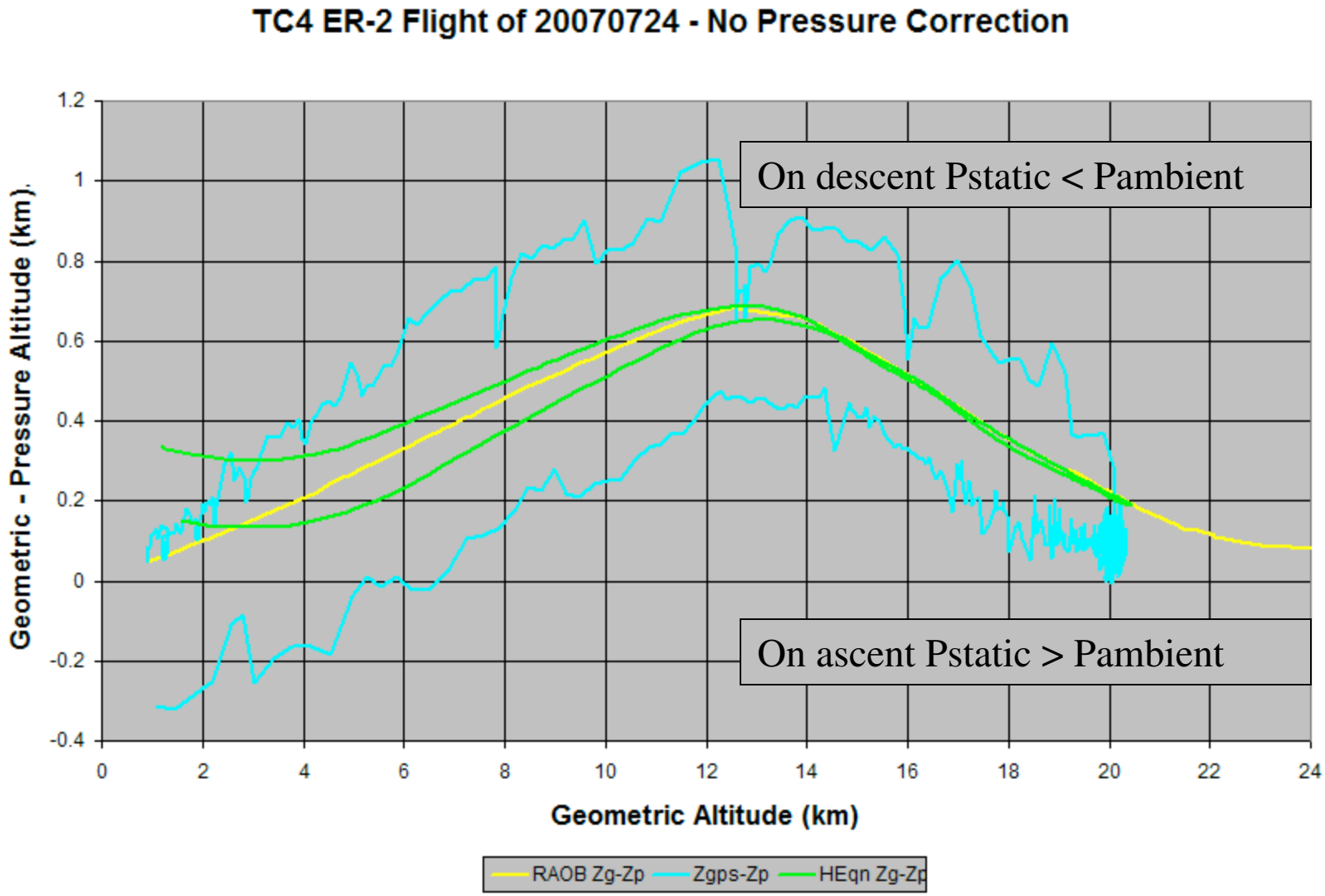


Answer: Compare the aircraft geometric minus pressure altitude (Zg-Zp) to that of a radiosonde launched near the flight track as a function of geometric altitude.

Zg-Zp Vs Zg Technique Applied to CAMEX-4 ER-2 Flight

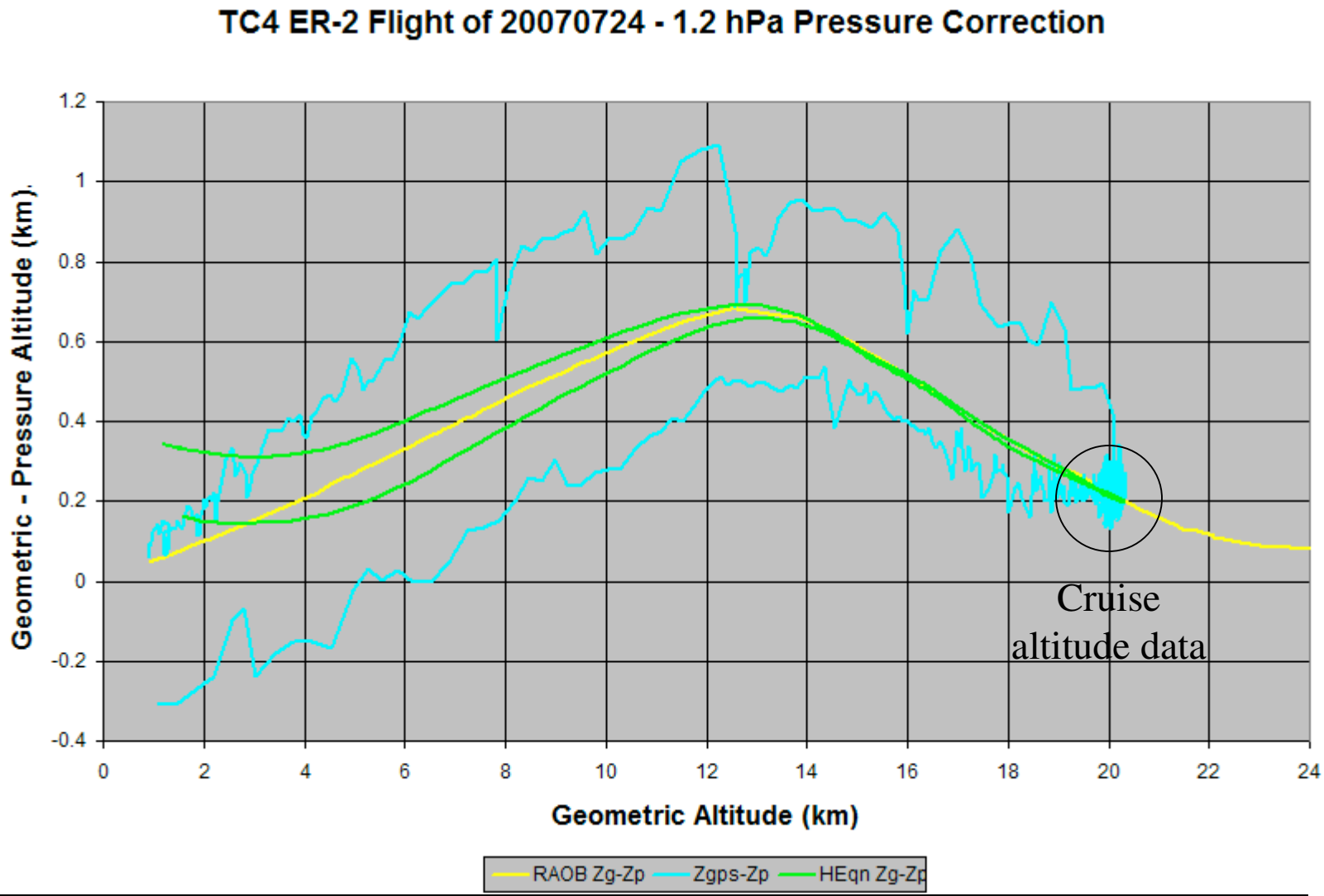


Zg-Zp Vs Zg Technique Applied to TC4 ER-2 Flight



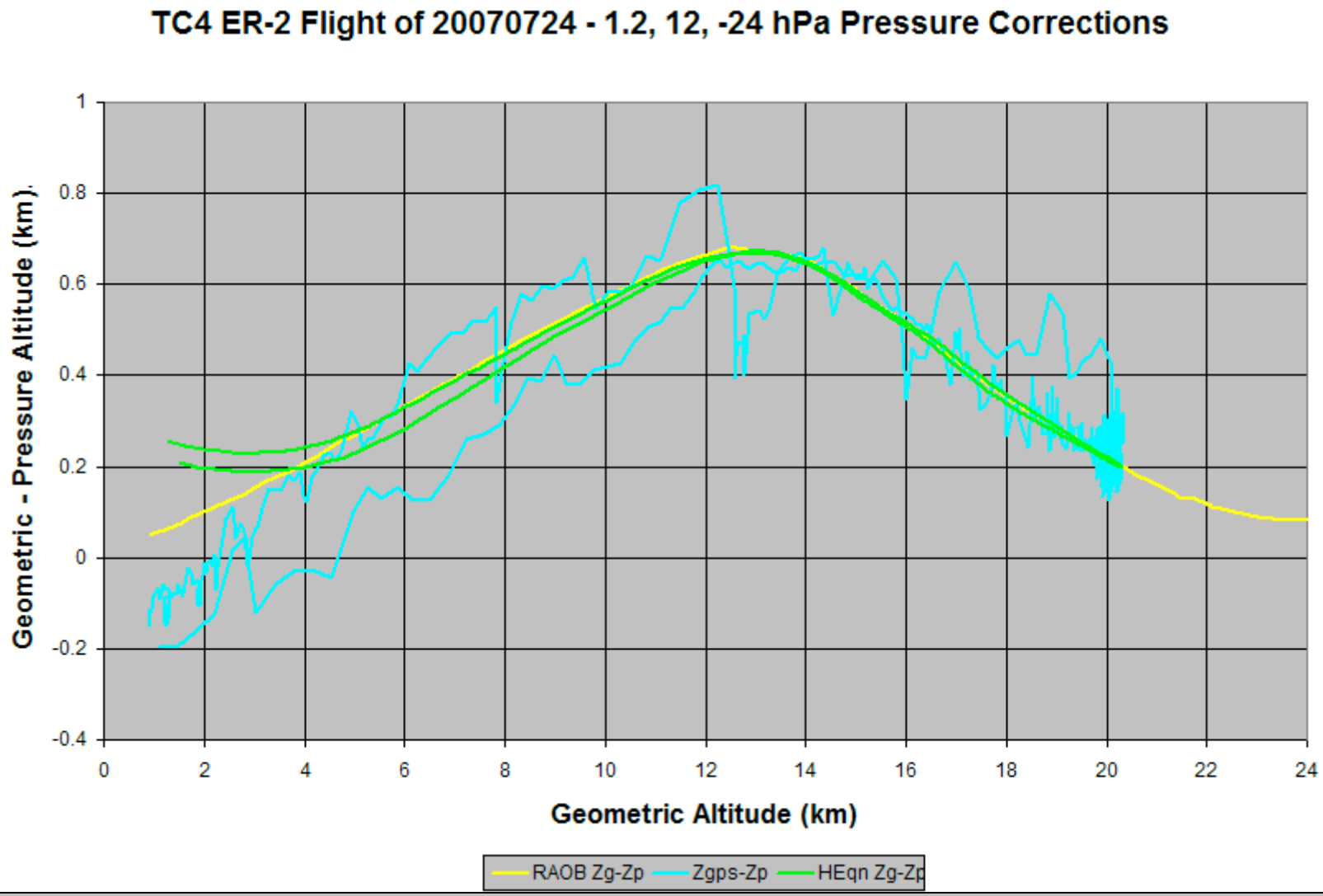
Raw ER-2 Zgps and Zp data (blue), MROC RAOB data (yellow), and ER-2 data integrated with hypsometric equation and arbitrary Pcorr to get Zg (green).

Zp-Zg Vs Zg Technique Applied to TC4 ER-2 Flight



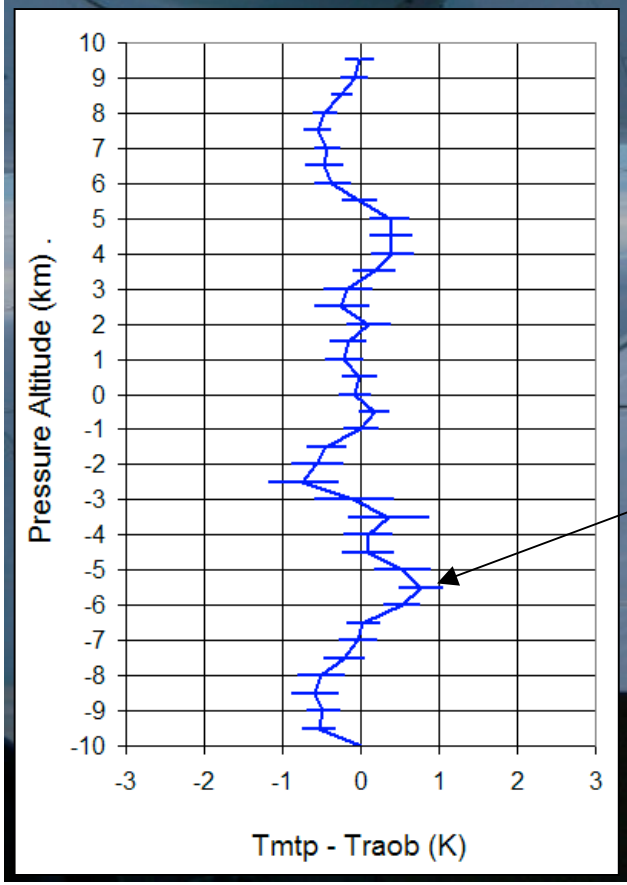
A +1.2 hPa static pressure correction bring the cruise data into agreement, but not the ascent and descent data.

Zp-Zg Vs Zg Technique Applied to TC4 ER-2 Flight



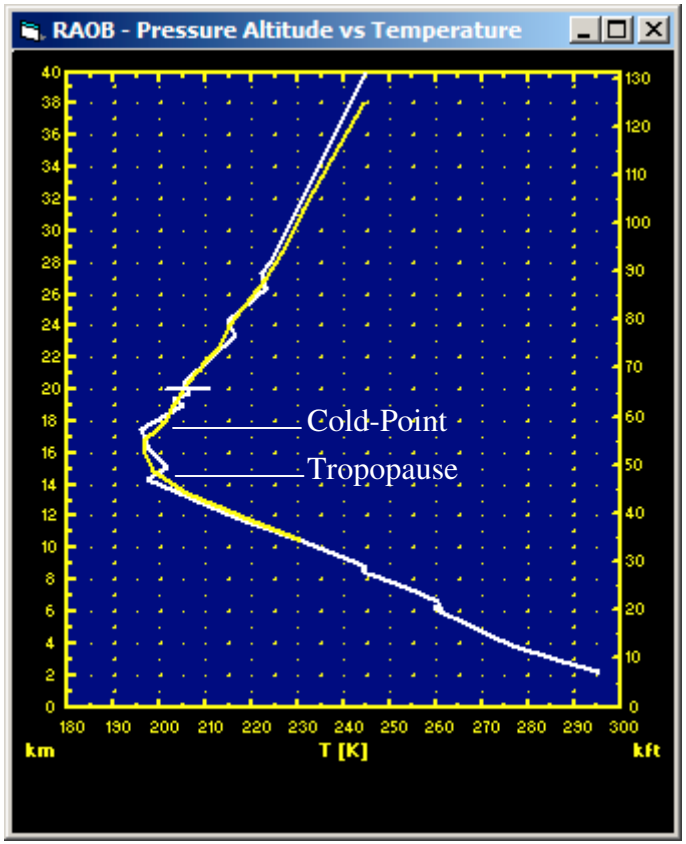
A +12.0 hPa static pressure correction as a function of altitude on ascent, and a -24.0 hPa static pressure correction as a function of altitude on descent help further.

MTP Performance during TC4



- The MTP retrievals (Tmtp) when compared to radiosondes (Traob) launched near the ER2's flight track agree to <1 K within 10 km of the flight altitude
- The warm bias 5-6 km below flight altitude occurs because the MTP's vertical resolution does not allow the tropical tropopause to be resolved.

Simulated Retrievals to Estimate Tropopause and Cold-Point Height and Temperature Corrections



An example of a simulated retrieval at 20 km (yellow) on one of hundreds of RAOBs (white) to determine the accuracy of the MTP tropopause and cold-point T and Z

ER-2 at 20 km

Ttrop = Tmtp - 1.9 (±0.2) K

Ztrop = Zmtp + 0.1 (±0.1) km

Tcp = Tmtp -1.8 (±0.2) K

Zcp = Zmtp + 0.1 (±0.1) km

ER-2 at 18 km

Ttrop = Tmtp - 1.8 (±0.2) K

Ztrop = Zmtp - 0.0 (±0.1) km

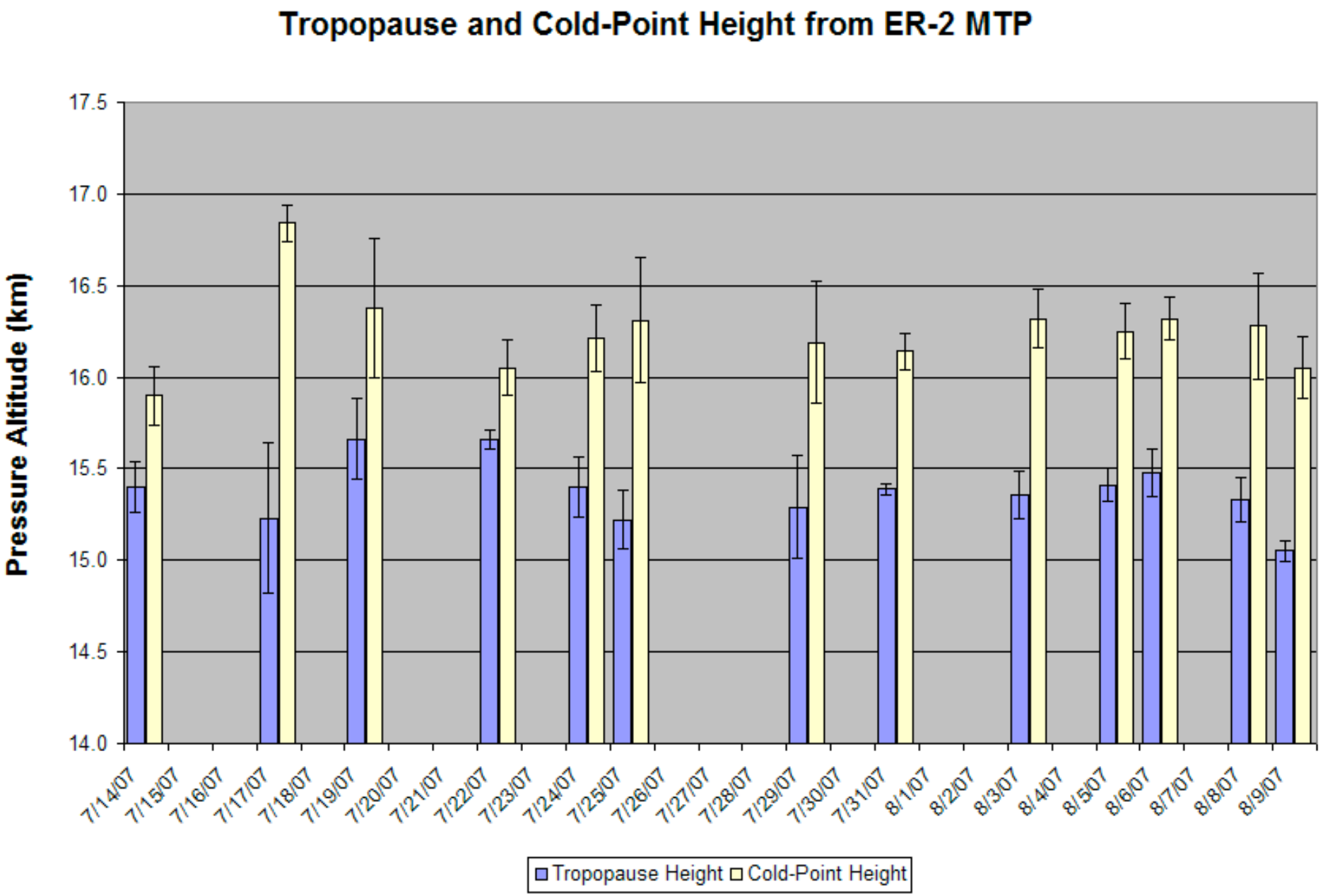
Tcp = Tmtp -1.7 (±0.2) K

Zcp = Zmtp - 0.1 (±0.1) km

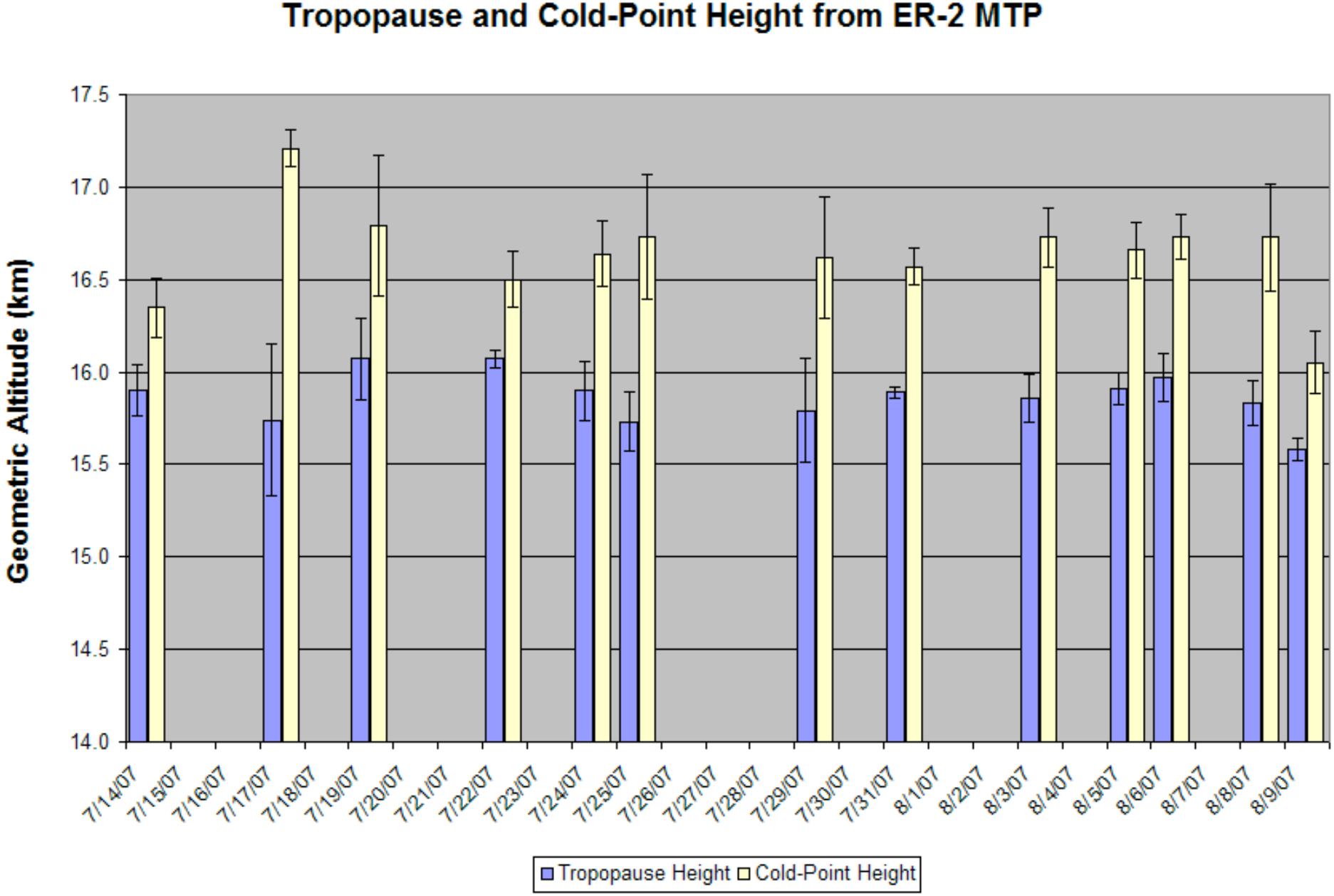
Conclusions:

MTP Ztrop and Zcp are okay

MTP Ttrop and Tcp 1.8 K warm

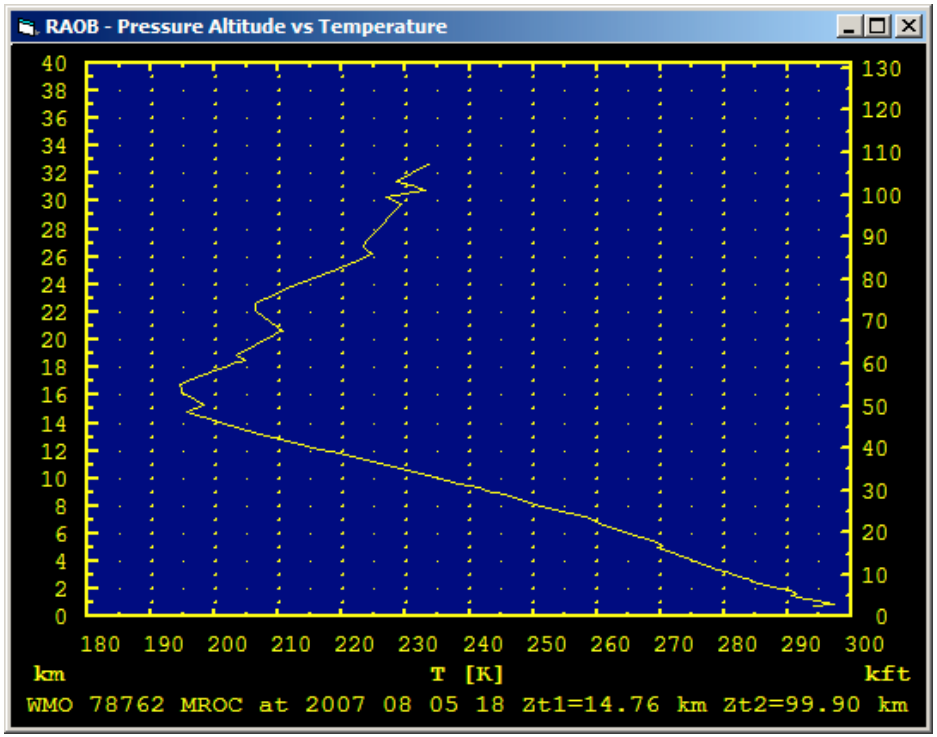


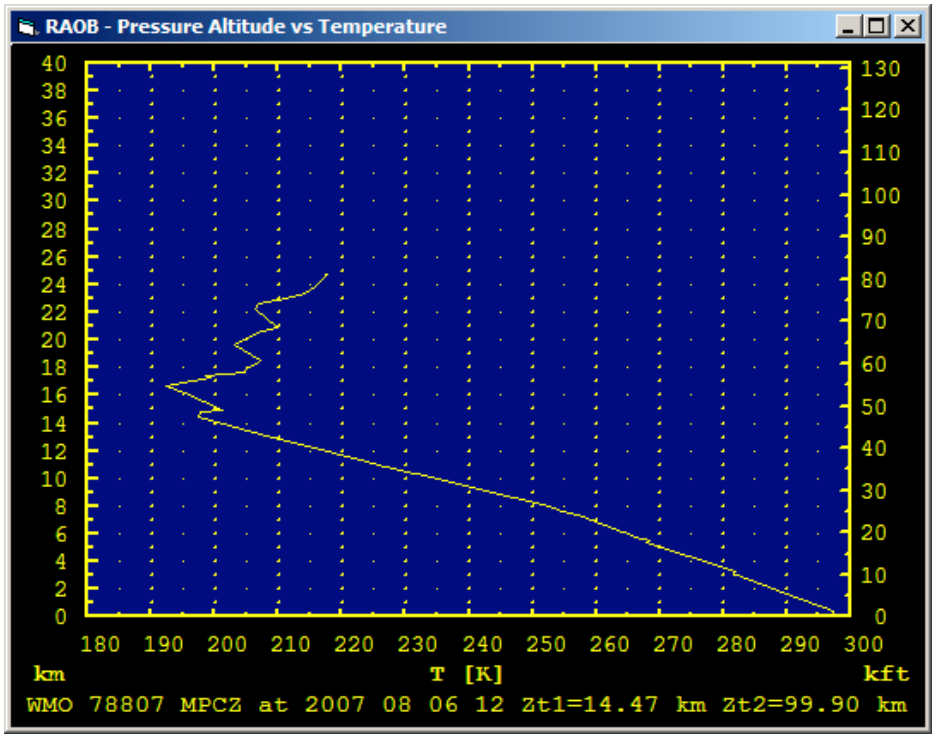
1-sigma error bars are the population standard deviation, not the SE on altitude measurement


Tropopause and Cold-Point Height from ER-2 MTP
Geometric Altitude (km)
17.5
17.0
16.5
16.0
15.5
15.0
14.5
14.0
7/14/07
7/15/07
7/16/07
7/17/07
7/18/07
7/19/07
7/20/07
7/21/07
7/22/07
7/23/07
7/24/07
7/25/07
7/26/07
7/27/07
7/28/07
7/29/07
7/30/07
7/31/07
8/1/07
8/2/07
8/3/07
8/4/07
8/5/07
8/6/07
8/7/07
8/8/07
8/9/07
Tropopause Height
Cold-Point Height

Two SVC Encounters Observed on WB-57 on 2007.08.05

Davis et al. report two SVC encounters on 2007.08.05, and CPL places their tops slightly above 15 km (geometric). The soundings below suggest the SVCs were below the tropopause, and not stratospheric. The MTP cold-point altitude agrees with these soundings, but the MTP could not resolve the weak tropopause inversion accurately from the 20 km ER-2 altitude.

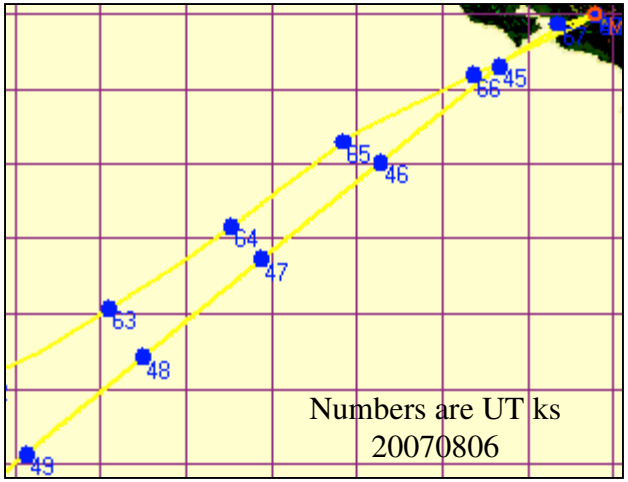




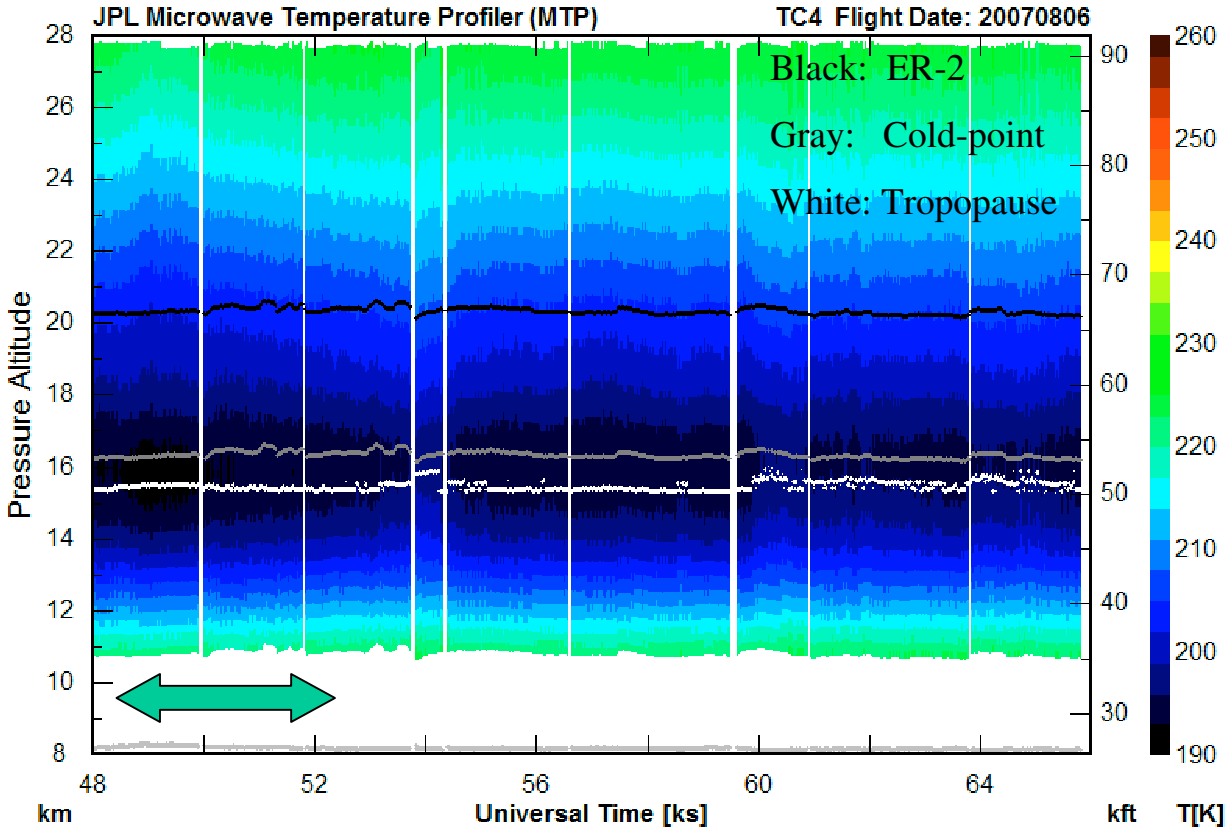
San Jose RAOB 2007.08.05 1800UT		
Altitude Scale	Pressure	Geometric
Tropopause	14.8 km	15.4 km
Cold-point	16.8 km	17.3 km

Corozal RAOB 2007.08.06 1200UT		
Altitude Scale	Pressure	Geometric
Tropopause	14.5 km	15.1 km
Cold-point	16.7 km	17.2 km

Sub-visible Cirrus (SVCs) Observed by WB-57 on 2007.08.06



SVCs were observed on the WB-57 corresponding to the period 45.5 to 49.0 ks on the ER-2 flight track (above).



Davis et al. report that during the period 13.4-14.5 hr (48.3-52.2 ks, green arrow above) UT SVCs were observed between 15.8-16.8 km (geometric). The average MTP tropopause and cold-point heights during this period were 15.4 and 16.4 km (pressure), respectively. These altitudes correspond to 15.8 and 16.8 km (geometric), placing the SVC entirely between the tropopause and the cold-point altitudes.

Conclusions

- The ER-2 Nav Data Recorder outside air temperature is worthless for science, and has been deteriorating over the years
- The MTP temperature profile retrievals are in excellent agreement with radiosondes
- Corrections to the MTP tropopause and cold-point height and temperature have been estimated by simulated retrievals
- MP-files with final data have been placed on the TC4 archive (2008.02.19)
- More MTP information including temperature curtain plots and flight tracks are available on the MTP we site at: http://mtp.jpl.nasa.gov/missions/tc4/tc4.html

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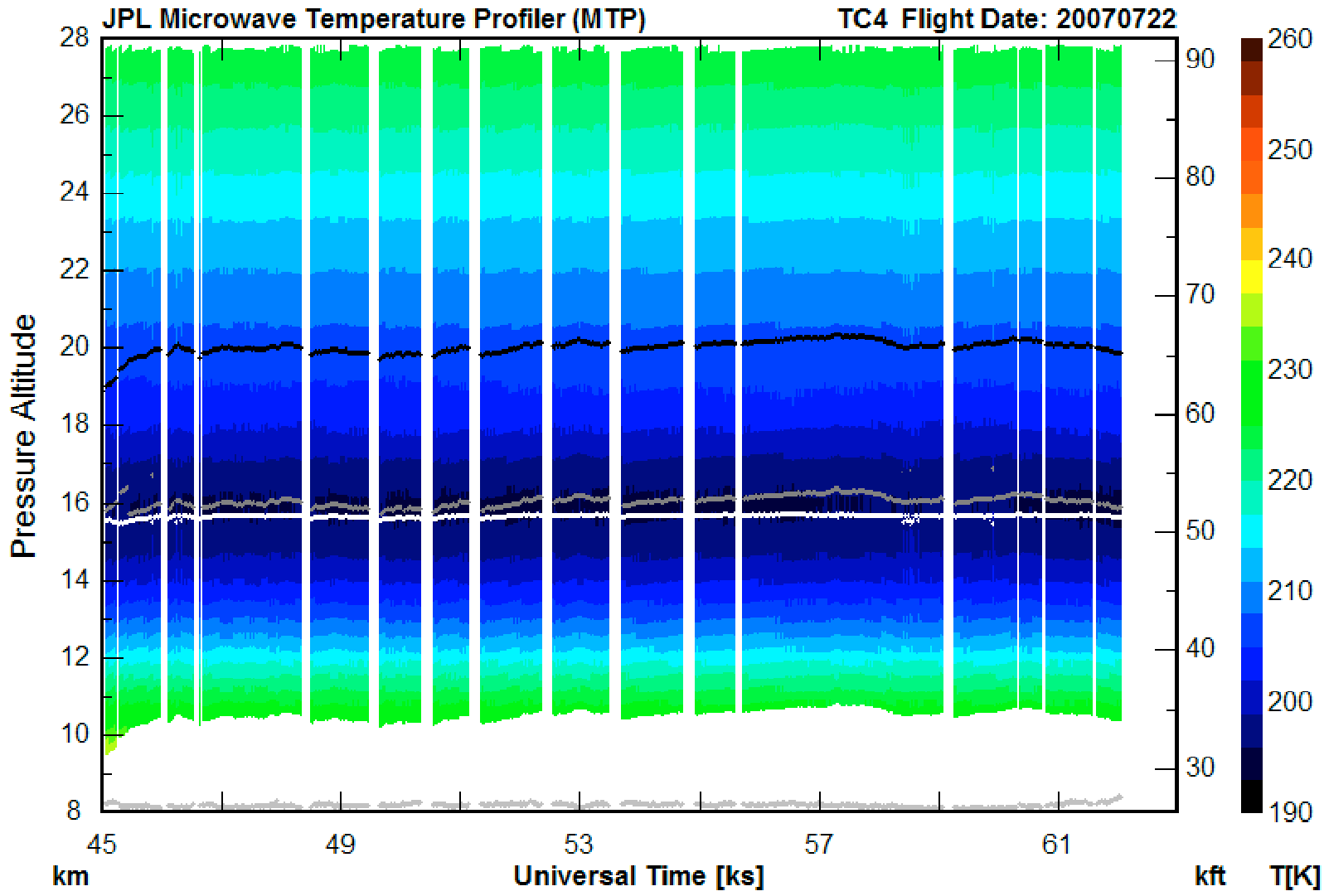
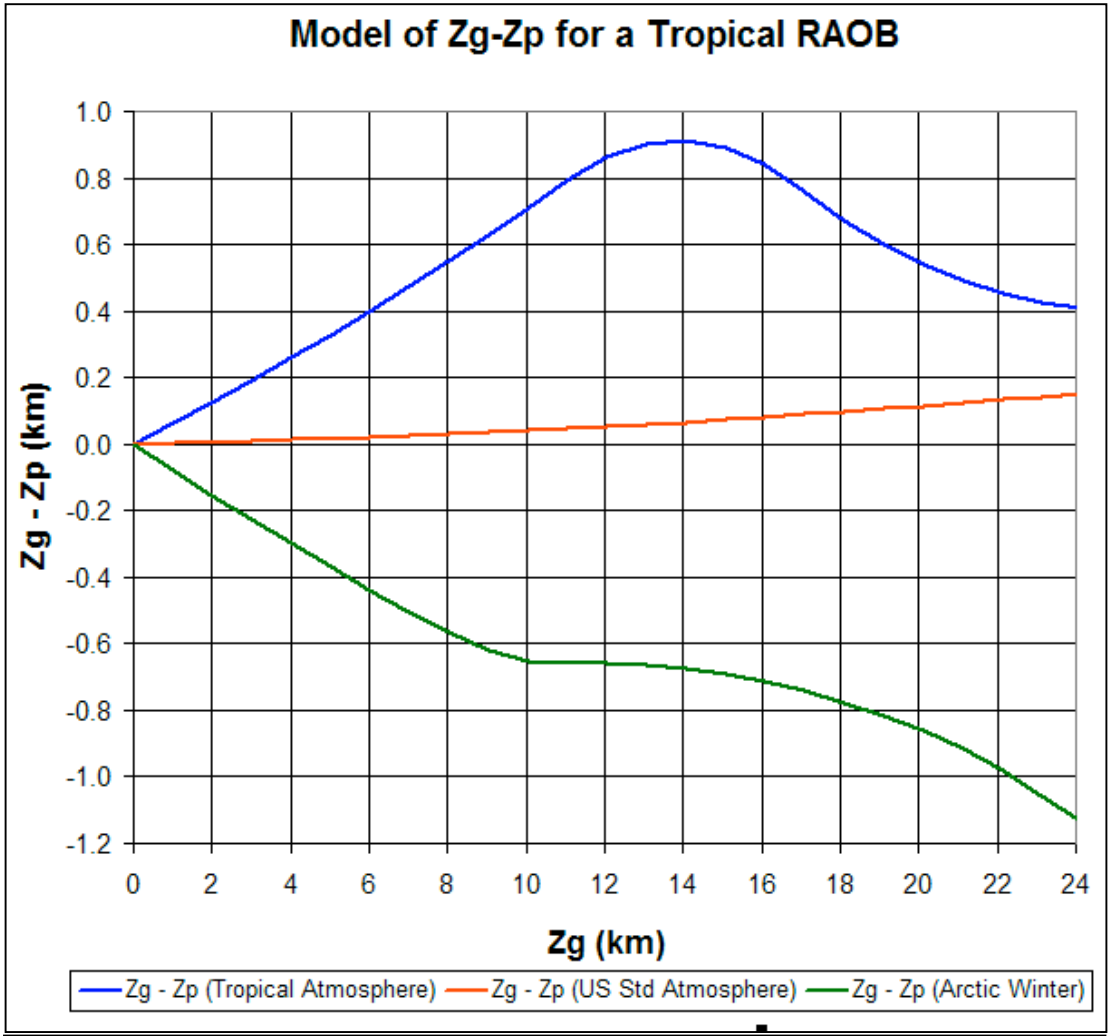
Backup Slides

MTP Temperature Curtains



Black = ER2 altitude, Gray = Cold-point altitude, White = Tropopause altitude

How to Determine if a Measured Outside Air Temperature is Valid



Answer: Compare aircraft Zg-Zp vs Zg to that of a radiosonde launched near the flight track

Model Parameters

Tropical Summer RAOB
To = 305 K
Lapse Rate = -6.5 K/km to 17 km
= +3.0 K/km to 40 km

US Standard Atmosphere
To = 288.15 K
Lapse Rate = -6.5 K/km to 11 km
= 0.0 K/km to 20 km
= +1.0 K/km to 32 km

Arctic Winter RAOB
To = 265 K
Lapse Rate = -5.6 K/km to 8 km
= -1.3 K/km to 23 km
= +1.2 K/km to 40 km

Zp = Pressure Altitude

Zg = Geometric Altitude

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